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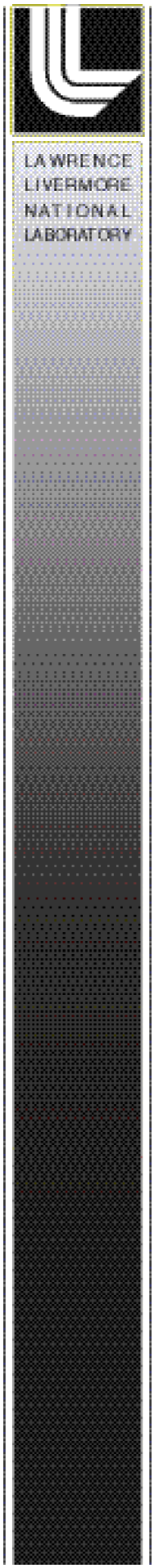

Collection of Solid Debris on NIF for Radiochemical Diagnostics and Measurements

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Disclaimer

Auspices Statement

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FY08 LDRD Final Report
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Abstract

A system for collecting solid, post-explosion debris samples from the NIF chamber and their subsequent radiochemical analysis is currently under development. If the debris that condenses out of the plasma can be collected and analyzed, the number and type of nuclear reactions that occurred in the capsule material can be determined. This has applications both for radiochemical diagnostics of NIF capsule performance as well as radiochemical measurements relevant to basic science and stockpile stewardship. Several design prototypes have been studied and a prioritized list of radiochemical measurements that could be performed on NIF is under development based on interactions with capsule design, fabrication, and WCI design divisions.

Introduction/Background

The fusion process that occurs within a NIF capsule produces neutrons, alpha particles, and scattered deuterons and tritons. These particles will interact with material in the capsule ablator and cause nuclear reactions to occur, resulting in activated species that emit characteristic radiation. If a material was intentionally "doped" in the NIF capsule, after the shot occurred, the debris that had condensed out of the plasma could be collected and radiochemically analyzed to determine the type and number of activations that took place on the doped material. This has two potential applications. The first is for ignition and capsule performance diagnostics. The number of activated species detected in the solid debris would give information about the drive asymmetry, average fuel ρR, and mix that occurred during the implosion, providing capsule designers with an important tool for diagnosing capsule failure modes. The second application is radiochemical measurements relevant to stockpile stewardship and basic science projects. By measuring the solid debris present after a NIF shot, cross section measurements required for radiochemical diagnostics and reduction of uncertainties can be made for elements with unknown or highly uncertain cross sections that are specifically added to the NIF capsule. Likewise, this same technique could be used for making measurements for basic science applications, most notably, nuclear science and astrophysics programs.

The purpose of this project is to begin designing a solid collection system for NIF and to perform supporting sensitivity studies. Collection of solid materials in NIF is an extremely complicated problem. The design of a collection mechanism must take several considerations into account, for instance, the interaction of plasmas with solids, the recoil range of slow-moving ions, background interferences, and material compatibility issues. These studies will require interfacing with NIF engineers, capsule designers, and target fabrication personnel. Design prototypes will be investigated and feasibility studies will be conducted on various collection models. In

addition, a prioritized list of radiochemical measurements will need to be developed based on interactions with capsule designers, target fabrication, and the WCI design divisions. Details regarding collector size, collector materials, and how the collector will be introduced and extracted from the chamber will be considered, along with new techniques for radiochemical processing and detection methods, possibly involving the use of automation.

Research Activities

Several concepts for solid debris collectors at NIF were developed as part of a LLNL-LANL-CSM (Colorado School of Mines) collaboration that was established for evaluation of solid collection methods. Major issues related to introduction and extraction of a collector from the NIF chamber, chemical form of the post-explosion capsule debris, and collector/debris materials interactions were identified. Discussions with NIF debris modeling and engineering were started to address these issues, ultimately leading to a prioritized list of collector designs. Sensitivity studies were also performed for some of the proposed cross section measurements to determine whether their detection in capsule debris would be plausible and for what range of laser energies. In addition, a prioritization of radiochemical measurements is under development through coordination with capsule designers, target fabrication and WCI designers.

Results/Technical Outcome

This feasibility study resulted in several design possibilities for NIF solid collection. The ideas that emerged include a debris focusing system (LANL), a hollow collection sphere (CSM) and the use of aerosolized salts to capture and direct debris onto an extraction surface (LLNL). The preliminary research performed under this project has led to an experimental plan for testing the premise of using salt aerosols to direct NIF debris. We are also working closely with our other collaborators on their proposed designs. NIF debris modeling is performing simulations that address the issues of the form of the debris and its velocity as it leaves the exploding capsule. These results will assist us in establishing optimized materials and solid angle for the collector in order to avoid any material incompatibilities. Sensitivity studies on cross section calculations have led to determinations of minimum concentrations of doped materials in the capsule ablator and minimum laser energy requirements. All of this work will continue under a recently funded LDRD-ER that is focused on collection of solid debris at NIF.

Exit Plan

The results from this feasibility study were successfully used to generate a full LDRD-ER proposal, which was funded through the WCI LDRD portfolio beginning in FY09.

Summary

A system for collecting post-shot debris samples from the target chamber following a NIF shot is under development through a collaboration with LANL and CSM. Several design possibilities have been established and are now being tested for their feasibility as collectors on NIF. Debris modeling is being used to address key issues that have been identified in conjunction with this project. Sensitivity studies and prioritization of radiochemical measurements that can be made on NIF

once solid collection has been established have begun. Collection of solid debris has future applications for capsule diagnostics, stockpile stewardship measurements and basic science experiments closely related to nuclear and astrophysics. This work will continue under a recently funded LDRD-ER.